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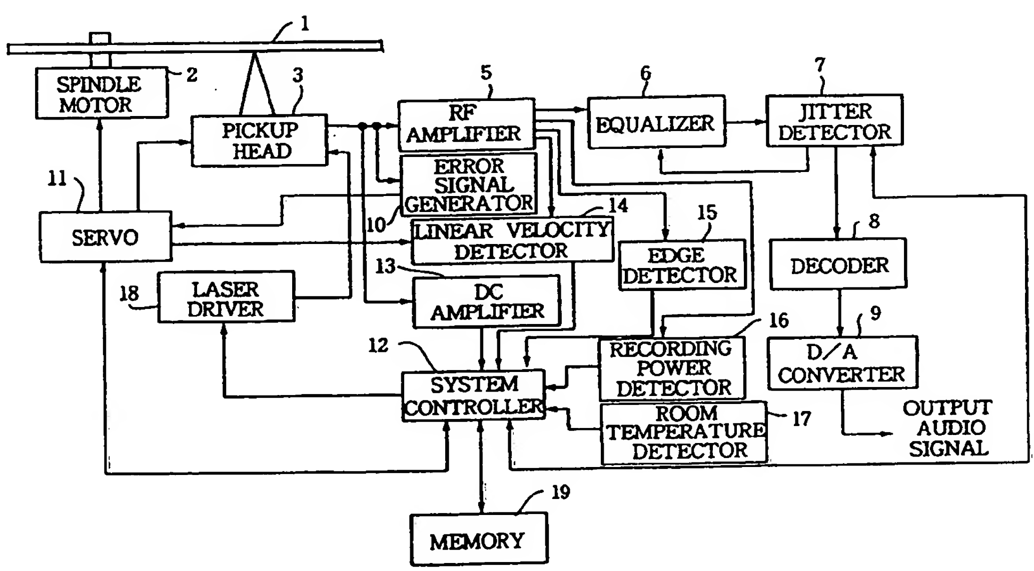
(54) Method of and apparatus for recording information on a writable optical disc.

(57) A test pit is formed in a power calibration area of a writable optical disc (1) by a pulse dependent on the recording conditions. Jitters included in a signal obtained by reproducing the test pit are detected, and the width of the test pulse is reduced so as to reduce the jitters. An optimum pulse is determined dependent on the result of the reduction of the pulse width and the optimum pulse is stored in a memory (19) for recording information.

FIG.1



BACKGROUND OF THE INVENTION

The present invention relates to a method of and an apparatus for recording information on an optical disc.

There are optical discs such as a CD including a read only CD and a writable CD-R disc which is used as a ROM. Further, as a writable optical disc having a high recording density, a write once disc and an erasable disc are available. Information is recorded on the disc and reproduced therefrom with a laser beam. These discs are different from a CD concerning the material of the recording surface.

For example, a write once (CD-WO) disc has a tellurium or bismuth recording surface in which the lasers burn pits for recording. In another type of the CD-WO discs, the lasers are focused on a recording surface coated with a selenium antimony (Sb_2Se_3) thin film, or an tellurium oxide (TeOx) thin film, or a thin film of an organic pigment, in order to change the reflectivity of the light.

An erasable disc uses a recording surface, consisting of an amorphous alloy made of rare earth metals such as gallium, terbium, and others. In a magneto-optical recording method, the recording surface of the disc is initially magnetized to form a magnetic field in a direction perpendicular to the surface. The laser heats a predetermined area of the disc to elevate the temperature above the Curie temperature, which is about 150 °C, thereby reversing the direction of the magnetic field. In order to read the recorded information, laser light is irradiated on the recording surface so that a polarized wave front rotates slightly as a result of the Kerr effect.

Thus only the polarized wave deflected by the rotation is read by a photodetector, thereby enabling a user to read the information.

In a CD-WO disc and an erasable disc, pits are formed in the disc by the laser in accordance with a pit-position recording method or a pit-edge recording method.

Figs. 4a and 4b show principles of the pit-position recording method and the pit-edge recording method, respectively. As shown in Fig. 4a, the pit-position recording method makes a circular pit corresponding to coded-data "1". To the contrary, as shown in Fig. 4b, the pit-edge recording method makes a pit having a leading edge and a trailing edge each of which corresponds to a coded-data "1". Thus, the pit-edge recording method can achieve a bit density twice as much as that of the pit-position method.

However, in the pit-edge recording method, if pits are formed in the optical disc based on data recording power pulses as shown in Fig. 5a, each of the pits obtains a tear-drop shape as shown in Fig. 5b because the heat supplied by the laser is accumulated in the disc.

Furthermore, if a pit P2 is formed after a pit P1 with a short distance therebetween as shown in Fig. 5c, the leading edge of the pit P2 shown by a dotted line is liable to shift toward the pit P1 shown by a solid line because of a thermal interaction between the pits. If pits of information are deformed, an RF signal may have jitters at the reproduction of the information, causing noises in the reproduced sound.

Fig. 6 shows a conventional method for suppressing such jitters which is called a multi-pulse recording method. In this method, a recording power pulse of a laser is slightly delayed with respect to an EFM signal (data pulses). The recording power pulse comprises a temperature elevating part and warm keeping part so as to equalize the temperature distribution on the disc. The warm keeping part comprises a plurality of fine pulses formed by slitting a trailing part of the power pulse. Since recording conditions of the discs vary with the type of the disc and room temperature at recording, it is necessary to change the recording power pulse in dependency on such conditions. It is very difficult to obtain optimum pits suitable for the conditions. In particular, since an optical disc of a CAV type has a differing linear velocity on the disc, it is necessary to vary the recording waveform in dependency on the linear velocity.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a method of and an apparatus for recording information whereby the information can properly be recorded on an optical disc.

According to the present invention, there is provided a method of recording information on a writable optical disc comprising: detecting conditions for recording information on the optical disc, forming a test pit in an area of the optical disc by a pulse dependent on the detected conditions, detecting jitters included in a signal obtained by reproducing the test pit, changing the width of the pulse so as to reduce the jitters, determining an optimum pulse dependent on the result of changing of the pulse width, storing the optimum pulse in a memory, and recording information on the optical disc with pulses dependent on the stored optimum pulse.

Also, according to the invention, there is provided an apparatus for recording information on a writable optical disc comprising: means for detecting conditions for recording information on the optical disc; means for forming a test pit in an area PCA of the optical disc by a pulse dependent on the detected conditions; means for detecting jitters

included in a signal obtained from a pickup by reproducing the test pit; means for changing the width of the pulse so as to reduce the jitters; means for determining an optimum pulse dependent on the result of the changing of the pulse width; means for storing the optimum pulse in a memory; and means for recording information on the optical disc with pulses dependent on the stored optimum pulse.

Other objects and features of this invention will become apparent from the following description of a preferred embodiment with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1
is a block diagram showing an optical pickup according to the present invention;
Fig. 2
is a diagram schematically showing areas of a CD-WO disc;
Fig. 3
is a flowchart showing an operation of the pickup;
Figs. 4a and 4b
are diagrams showing principles of pit-position and pit-edge recording methods, respectively;
Figs. 5a to 5c
are diagrams showing data pulses and deformed pits recorded by the data pulses; and
Fig. 6
shows a diagram showing a conventional multipulse recording method.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, a recording system of an optical pickup according to the present invention comprises a CD-WO disc 1 secured to a spindle of a spindle motor 2 to be rotated by the spindle motor 2, and an optical pickup head 3 producing a laser beam for recording information on the disc 1 and reproducing the recorded information on the disc. A servo 11 is connected to the pickup head 3 for tracking and focusing the beam from the pickup head 3 on the disc 1, and is connected to the spindle motor 2 for controlling the rotating speed of the spindle motor 2 based on a control signal supplied from a system controller 12. A laser driver 18 is connected to the pickup head 3 for properly adjusting the power of the laser from the pickup head 3 based on a control signal from the system controller 12.

The pickup head 3 reads out the information on the recording surface of the CD-WO disc 1 and produces a reproduced RF signal which is supplied to an RF amplifier 5. In the RF amplifier 5, the RF signal is amplified and the amplified signal is supplied to an equalizer 6 for equalizing the frequency characteristic of the signal. An output signal of the equalizer 6 is supplied to a jitter detector 7 where jitters in the signal is detected. An output signal of the jitter detector 7 is applied to a D/A converter 9 through a decoder 8. In the D/A converter 9, the signal is converted into an analog signal in order to produce an audio signal.

The signal from the pickup head 3 is further applied to an error signal generator 10. The error signal generator 10 generates a tracking error signal and a focus error signal which are applied to the servo 11. The servo 11 applies a signal to the pickup head 3 so as to control it and to compensate the tracking error and the focus error so that their values become zero.

In order to determine an optimum condition for recording information on a disc, the recording system is provided with a DC amplifier 13 supplied with the signal from the pickup head 3, a linear velocity detector 14, an edge detector 15 and a recording power detector 16 which are supplied with the output signal from the RF amplifier 5, and a room temperature detector 17.

The DC amplifier 13 detects the reflectivity of the disc 1 in accordance with the signal from the pickup head 3. The linear velocity detector 14 is further supplied with the rotating speed signal of the spindle motor 2 from the servo 11 and a position signal detected by a position sensor (not shown) representing the position of the pickup head 3 in the radial direction of the disc 1. The linear velocity detector 14 detects the linear velocity of the disc at the spot of the laser on the disc 1, based on the input signals.

The edge detector 15 detects a leading edge and a trailing edge of a pit on the disc 1 to obtain the length of a reproducing pit. The recording power detector 16 detects a recording power of test pits formed on the disc 1 at a power calibration area (PCA) of the CD-WO disc 1. The room temperature detector 17 comprises a thermocouple and detects a room temperature when recording information on the disc 1. These signals from the DC amplifier 13 and the detectors 14, 15, 16 and 17 are applied to a memory 19 through the system controller 12 and stored therein.

As shown in Fig. 2, the PCA is provided on the innermost portion of the disc 1 inside of a program memory area (PMA) for calculating a recording power based on the detected recorded power of the test pits.

The operation of the system for obtaining the optimum condition of the disc 1 for recording information will be described with reference to the flowchart of Fig. 3. Operation is performed by a

manufacturer of the player.

At a step 601, the room temperature is detected by the room or ambient temperature detector 17 and stored in the memory 19. At a step 602, the pickup head 3 is moved to the PCA, where a test pulse is recorded to form a test pit on the PCA. The recording power pulse of the test pulse is determined by the power detected by the recording power detector 16. An optimum recording power for recording information on the disc 1 is calculated based on the determined recording power pulse, and the calculated recording power is stored in the memory 19 in the form of a pulse. In the operation if a disc 1 of a CAV type is used, the ratio of the linear velocity detected by the linear velocity detector 14 to the recording power is obtained and stored in the memory 19 at a step 603. At a step 604, the reflectivity of the disc 1 is detected by the DC amplifier 13 and stored in the memory 19. At a step 605, the length of the recorded pit is detected by the edge detector 15 and stored in the memory 19.

At a step 606, the leading edge of the calculated power pulse is slightly cut away and the information of a new test pit by the cut power pulse is reproduced again. At a step 607, it is determined whether the jitter detected by the jitter detector 7 is reduced compared with the last time or not. If the jitter is reduced, the program goes to a step 608 where the leading edge is further cut. The program returns to the step 606. If the jitter is not reduced at the step 607, the program goes to a step 609 where the cutting amount of the leading edge of the power pulse having less jitter is determined and stored in the memory 19.

At a step 610, the trailing edge of the power pulse is cut and the information of a new test pit is reproduced again. At a step 612, it is determined whether the jitter detected by the jitter detector 7 is reduced compared with the last time or not. If the jitter is reduced, the program goes to a step 611 where the trailing edge is further cut. The program returns to the step 610. If the jitter is not reduced at the step 612, the program goes to a step 613 where the cutting amount of the trailing edge having less jitter is determined and stored in the memory 19.

At a step 614, the number of fine pulses in the warm keeping part of the power pulse is increased and the information of a new test pit is reproduced again.

At a step 615, it is determined whether the jitter detected by the jitter detector 7 is reduced compared with the last time or not. If the jitter is reduced, the program goes to a step 616 where the number of fine pulses is further increased. The program returns to the step 614. If the jitter is not reduced at the step 615, the program goes to a step 617 where the number of fine pulses having less jitter is determined and stored in the memory 19.

At a step 618, recording information on the program area of the disc 1 is started based on the optimum condition stored in the memory 19.

Such an operation is performed on various types of discs 1 to obtain respective optimum conditions which are stored in the memory 19. Thus, the optimum condition corresponding to the different types of discs can be retrieved from the memory 19 by a user.

Even if the various factors such as room temperature vary during recording the information, the optimum condition of the disc is obtained. Furthermore, if a CAV disc is used, it is possible to change the recording power based on the result detected by the linear velocity detector 14. Thus, a proper pit for the disc 1 is easily formed.

Since the system has a self-learning function, the optimum condition stored in the memory 19 is updated in dependency on variations of the condition with time.

Thus, noises of the signal are reduced, so that information is properly reproduced.

While the presently preferred embodiment of the present invention has been shown and described, it is to be understood that this disclosure is for the purpose of illustration only and that various changes and modifications may be made without departing from the scope of the invention.

Claims

1. A method of recording information on a writable optical disc (1) comprising:
   - detecting conditions (13, 14, 16, 17) for recording information on the optical disc (1);
   - forming a test pit (18) in an area (PCA) of the optical disc (1) by a pulse dependent on the detected conditions;
   - detecting jitters (7) included in a signal obtained by reproducing the test pit;
   - changing the width of the pulse (12, 18) so as to reduce the jitters;
   - determining an optimum pulse (13) dependent on the result of the changing of the pulse width;
   - storing the optimum pulse in a memory (19); and
   - recording information on the optical disc (1) with pulses dependent on the stored optimum pulse.

2. The method according to claim 1, wherein the recording conditions (14, 16, 17) include the ambient temperature (17), the re-

cording power (16), the reflectivity (13) of the optical disc (1), and the linear velocity (14) of the disc.

3. The method according to claim 1 or 2, wherein the changing of the pulse width comprises cutting the leading edge and the trailing edge of the pulse, and slitting a trailing part of the pulse for a plurality of fine pulses.

4. An apparatus for recording information on a writable optical disc (1) comprising:
   - means (13, 14, 15, 16, 17) for detecting conditions for recording information on the optical disc (1);
   - means (18) for forming a test pit in an area (PCA) of the optical disc (1) by a pulse dependent on the detected conditions;
   - means (5, 6, 7) for detecting jitters included in a signal obtained from a pickup (3) by reproducing the test pit;
   - means (12, 18) for changing the width of the pulse so as to reduce the jitters;
   - means (13) for determining an optimum pulse dependent on the result of the changing of the pulse width;
   - means (12, 19) for storing the optimum pulse in a memory (19); and
   - means (12, 18) for recording information on the optical disc (1) with pulses dependent on the stored optimum pulse.

5. The apparatus according to claim 4, wherein the means (13, 14, 15, 16, 17) for detecting conditions comprise a DC amplifier (13) for the reflectivity of the disc (1), a linear velocity detector (14) for the linear velocity of the disc (1), a recording power detector (16) and an ambient temperature detector (17).

6. The apparatus according to claim 4 or 5, wherein an edge detector (15) is provided for detecting the leading edge and the trailing edge of the respective pits formed in the optical disc (1).

FIG.1

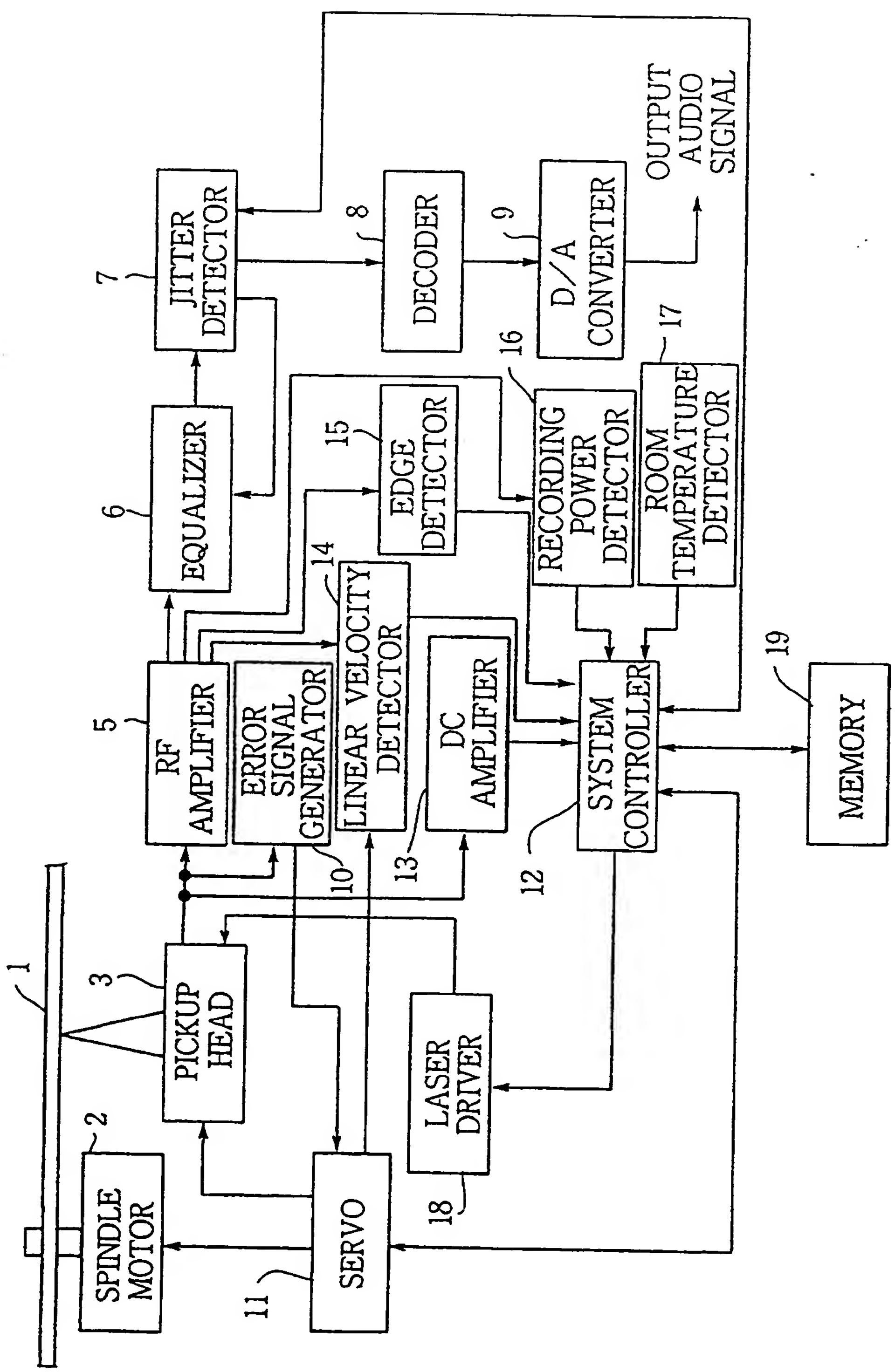

1
2
SPINDLE MOTOR
3
PICKUP HEAD
11
SERVO
18
LASER DRIVER
5
RF AMPLIFIER
ERROR SIGNAL GENERATOR
10
14
LINEAR VELOCITY DETECTOR
13
DC AMPLIFIER
12
SYSTEM CONTROLLER
19
MEMORY
6
EQUALIZER
15
EDGE DETECTOR
16
RECORDING POWER DETECTOR
17
ROOM TEMPERATURE DETECTOR
7
JITTER DETECTOR
8
DECODER
9
D/A CONVERTER
OUTPUT AUDIO SIGNAL

FIG.2

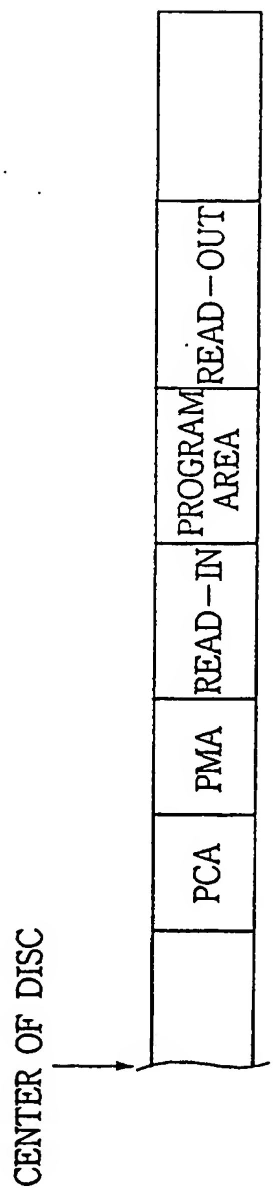


FIG.3

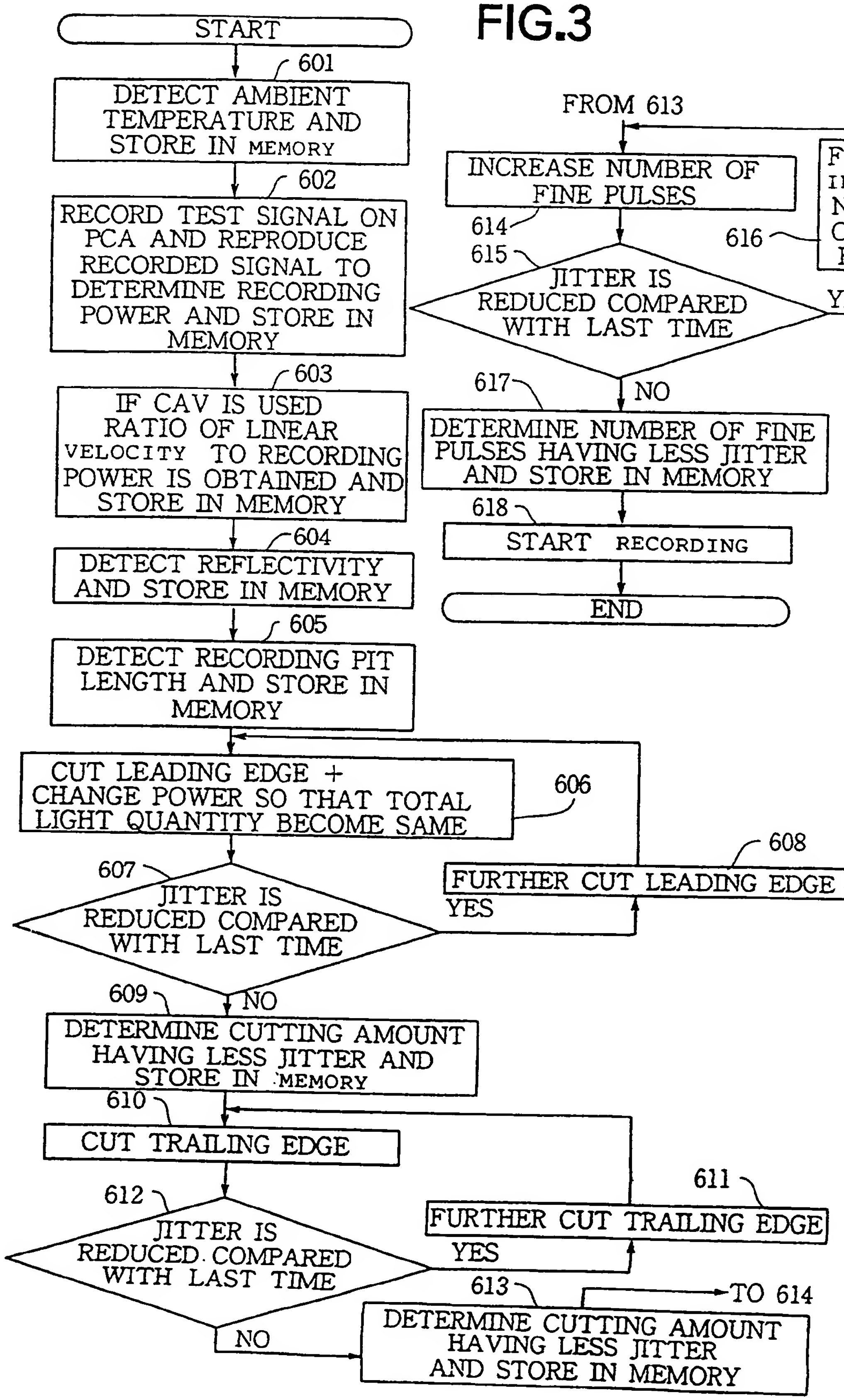

START
601
DETECT AMBIENT TEMPERATURE AND STORE IN MEMORY
602
RECORD TEST SIGNAL ON PCA AND REPRODUCE RECORDED SIGNAL TO DETERMINE RECORDING POWER AND STORE IN MEMORY
603
IF CAV IS USED RATIO OF LINEAR VELOCITY TO RECORDING POWER IS OBTAINED AND STORE IN MEMORY
604
DETECT REFLECTIVITY AND STORE IN MEMORY
605
DETECT RECORDING PIT LENGTH AND STORE IN MEMORY
606
CUT LEADING EDGE + CHANGE POWER SO THAT TOTAL LIGHT QUANTITY BECOME SAME
607
JITTER IS REDUCED COMPARED WITH LAST TIME
YES
608
FURTHER CUT LEADING EDGE
NO
609
DETERMINE CUTTING AMOUNT HAVING LESS JITTER AND STORE IN MEMORY
610
CUT TRAILING EDGE
612
JITTER IS REDUCED COMPARED WITH LAST TIME
YES
611
FURTHER CUT TRAILING EDGE
NO
613
DETERMINE CUTTING AMOUNT HAVING LESS JITTER AND STORE IN MEMORY
TO 614
FROM 613
614
INCREASE NUMBER OF FINE PULSES
615
JITTER IS REDUCED COMPARED WITH LAST TIME
YES
616
FURTHER INCREASE NUMBER OF FINE PULSES
NO
617
DETERMINE NUMBER OF FINE PULSES HAVING LESS JITTER AND STORE IN MEMORY
618
START RECORDING
END

FIG.4 a

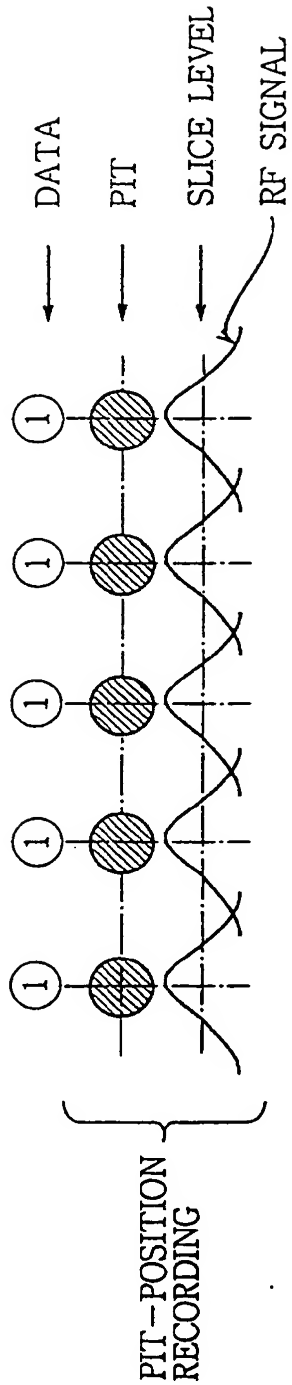

DATA
PIT
SLICE LEVEL
RF SIGNAL
1
PIT-POSITION RECORDING

FIG.4 b

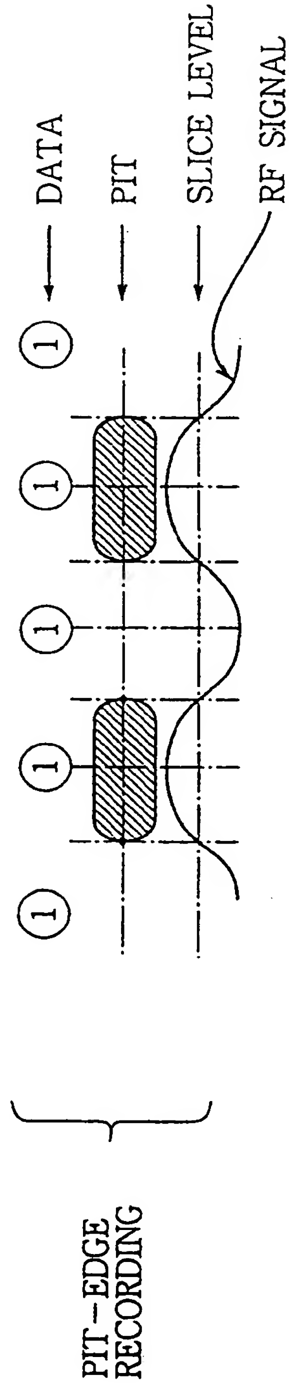

DATA
PIT
SLICE LEVEL
RF SIGNAL
1
PIT-EDGE RECORDING

FIG.5 a

FIG.5 b

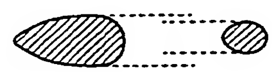


FIG.5 c

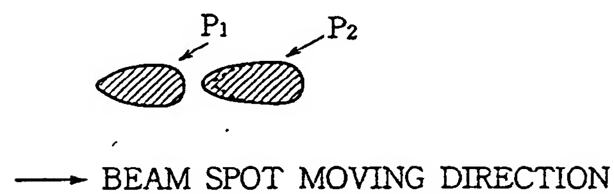
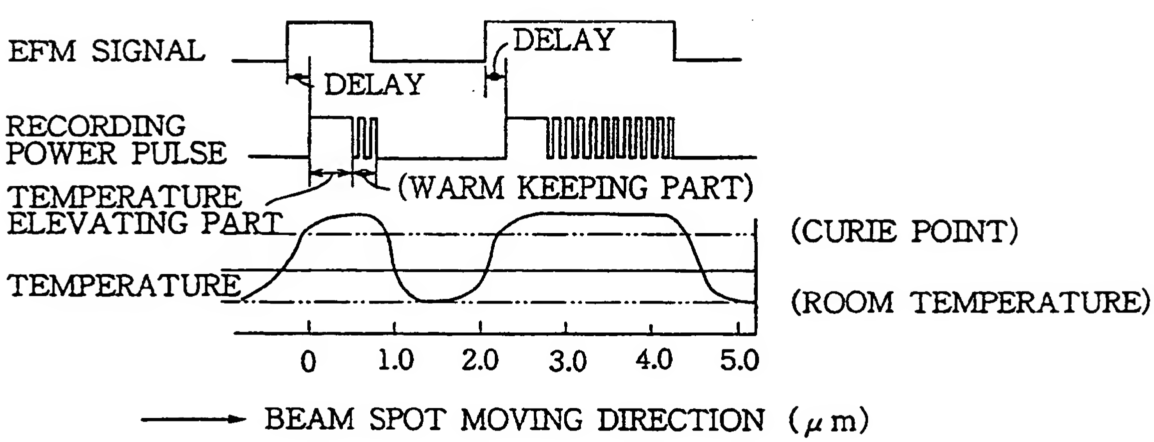


FIG.6



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EUROPEAN SEARCH REPORT

Application Number

EP 92 11 8827
Page 1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 404 249 (N V PHILIPS' GLOIELAMPENFABRIEKEN) * abstract * * column 11, line 52 - column 12, line 54 * ---	1,3,4	G11B7/00 G11B7/125
Y	EP-A-0 405 610 (MATSUSHITA ELECTRIC IND CO) * the whole document * ---	1,3,4	
A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 105 (P-354)(1828) 9 May 1985 & JP-A-59 227 043 (CANON K K) 20 December 1984 * abstract * ---	1,2,4	
A	EP-A-0 430 649 (MATSUSHITA ELECTRIC IND CO) * abstract * ---	1,4	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 312 (P-509)(2368) 23 October 1986 & JP-A-61 122 932 (CANON INC) 10 June 1986 * abstract * ---	1,4	TECHNICAL FIELDS SEARCHED (Int. Cl.5) G11B
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 176 (P-214)(1321) 4 August 1983 & JP-A-58 080 138 (TEAC K K) 14 May 1983 * abstract * ---	1,4	
A	EP-A-0 466 073 (SONY CORP) * abstract * --- -/--	2	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 MAY 1993	ANNIBAL P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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EUROPEAN SEARCH REPORT

Application Number

EP 92 11 8827
Page 2

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 18 (P-250)(1455) 26 January 1984 & JP-A-58 177 534 (MATSUSHITA DENKI K K) 18 October 1983 * abstract * ---	2	
A	US-A-4 937 809 (MIYADERA ET AL) * abstract * -----	2	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

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T : theory or principle underlying the invention
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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